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Herpetofauna of Engabao, Playas Canton, Ecuador, with notes on the occurrence of *Ceratoprhys stolzmanni* (Steindachner, 1882)

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Abstract
The Ecuadorian coast ecosystems are considered fragile due to anthropic activities, such as livestock production and agriculture, which are important economically. In this study, we document the herpetofauna of Engabao, in Playas Canton, Ecuador, and extend the distribution range of one species of frog. We performed day and night sampling, including transect surveys and visual encounters. Ten species of amphibians and reptiles were recorded. Included among these species the Threatened *Ceratophrys stolzmanni* (Steindachner, 1882). Engabao is an area intended for livestock production.

Keywords
Agricultural land, amphibians, dry thorn scrub, livestock, reptiles.

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Introduction

The ecosystems of the Ecuadorian coast harbor a large number of species of flora and fauna; however, these are currently considered some of the most fragile ecosystems in the country due to anthropic activities (Reyes-Puig et al. 2017). The coastal region of Ecuador is represented by several vegetation types, including dry thorn scrub, garuas stationary forest, tropical deciduous dry forest, and moist forest, and, therefore, the composition of the flora and fauna changes drastically across the area (MAE 2013). Cattle raising and agriculture, among other activities are of great economic importance in the region and sustain the local human communities (Sangoluisa 2017), such as in Engabao, a coastal town in Playas Canton, province of Guayas, Ecuador. Cattle raising has become a prominent activity among the residents of Engabao, and, as a consequence, similar to many other towns in the coastal region of Ecuador, the landscape has undergone transformation, which may impact local biodiversity.

The herpetofauna is an important component of biodiversity and represents feeding resources for predators (e.g. birds and mammals), guarantees the energy flow in the ecosystem, and ensures the survival of diverse species (Heatwole 1982; Deichmann et al. 2011). Amphibians and reptiles are also considered excellent controllers of insect pests and dispersers of seeds, including in disturbed areas, such as production lands (Valencia-Aguilar et al. 2013). The herpetofauna is also often used as a bioindicator of ecosystem health (quality) because several species of amphibians and reptiles are sensitive

or resilient to environmental changes (e.g. fragmentation, climate variation) (Markle et al. 2018; Read 2002). Although there has been effort to characterize the diversity of the Ecuadorian coastal ecosystems, the most relevant studies are restricted to the tropical rain forest of Choco (Altamirano-Benavides and Ortega-Andrade 2010; MECN et al. 2013; Torres-Carvajal et al. 2018; Ron et al. 2019). However, the central and southern coastal regions, where Engabao is located, differs in landscape structure to the Choco ecosystem and, accordingly, the species composition differs.

There have been few herpetofauna inventories performed in the central and southern coastal regions. For instance, in Santa Elena province, 21 species of amphibians were reported in Loma Alta, and 12 species in Dos Mangas (Salvatierra et al. 2010; Amador and Martínez 2011; Amador-Oyola 2016). These studies were undertaken in two remnant patches of the mountain and foothills garuas stationary forests (MAE 2013). In Guayas province, 10 species of amphibians and 10 of reptiles were reported at Bosque Protector Cerro Blanco, a remnant tropical dry forest (Amador and Martínez 2011; Almendáriz and Carr 2012; MAE 2013). In fact, these studies represent the only works carried out in the area. Thus, little is known about the herpetofauna of the dry thorn scrub ecosystem, where 16 species of anurans and 46 species of reptiles are reported (Torres-Carvajal et al. 2018; Ron et al. 2019).

This work presents the first assessment of the amphibian and reptile diversity at Engabao, Playas Canton, Ecuador. We include ecological notes for each species observed. We also report expand the geographic distribution of *Ceratophrys stolzmanni* (Steindachner, 1882), Pacific Horned Frog, which has been categorized as Vulnerable by the International Union for the Conservation of Nature (IUCN SSC Amphibian Specialist Group 2018).

Methods

Our study was carried out in El Algarrobo farm in the community of Engabao, Playas Canton (approximate center at 02°36′S, 080°26′W, 12 m a.s.l.). The study area covers 16.72 ha, most of which is dry thorn scrub, but a part of the farm is used for production (cattle raising and local crops). The annual average precipitation is 333 mm and annual mean temperature is 24.3 °C (Climate-Data.org 2019). We selected four sites for sampling: two sites were established inside the farm (A and B), while two other sites (C and D) were in open dry thorn scrub located south of the road running through the farm (Fig. 1). In the farm (sites A and B), the cattle are in an area enclosed for livestock. During the wet season, a small stream runs along the western boundary of the farm. The remaining area of the farm is designated either for local fruit crops or for patches of native vegetation. Sites C and D have two permanent ponds, and cattle graze the area daily.

Data collection. We performed five sampling expeditions (three days each) once every two weeks, starting on 1 March and ending 30 April 2019. This period corresponds to the transition between the wet and dry seasons. Diurnal and nocturnal surveys were performed by two collectors to maximize the chances of sighting animals. We established one transect per site (200 m × 4 m) separated to other sites by at least 50 m, which were visited twice per expedition. We recorded all individuals captured, sighted, or heard during the transect surveys. At both sites, we also performed random meander surveys in the areas adjacent to the water ponds, crops, and a representative area of the dry thorn scrub.

Surveys were performed during the day between 9:30 and 17:30 and at night between 18:00 and 24:00. Specimens were collected by hand or by noose using a Cabela rod and kept in plastic or cloth bags for identification. Most animals were released after identification, but some were collected for museum specimens. These were euthanized using 2% Roxicaine, fixed in 10% formalin solution and preserved in 70% alcohol. Specimens were collected under the permit No. 010-2019-IC-FLO/FAU-DPAG/MAE approved by the Ministerio del Ambiente – Ecuador and are deposited at the collection of the Museum of Universidad de Guayaquil.

Results

We recorded 167 individuals of 10 species belonging to 10 genera and eight families; 99 individuals were found in the farm (sites A and B) and 68 in the cattle grassing area (Table 1). For reptiles, Iguanidae and Colubridae were the most represented, followed by Gekkonidae and Teiidae. For amphibians, we reported four species belonging to Ceratophryidae, Leptodactylidae, Bufonidae, and Hylidae, of which *Ceratophrys stolzmanni* is a newly recorded species for the area.

Thus, most individuals were observed inside the farm (sites A and B), where the most abundant species was *Microlophus occipitalis*. At sites C and D, most amphibians were found near the pond in the dry thorn scrub, such as *Scinax quinquefasciatus*, which was exclusively found in the open dry thorn scrub. Snakes were only found hidden in rubble or house debris exclusively at site B, whereas *Medopheos edracantha* was unique to the farm.

Squamata
Family Colubridae Oppel, 1811

***Leptodeira septentrionalis* (Kennicott, 1859)**
Figure 2A

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 specimen (sex undetermined), 330 mm; human settlements (inside an abandoned house); 02°36′41″S, 080°26′14″W; 12 m a.s.l; 31 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R161 • 1 individual (sex undetermined), 307 mm;

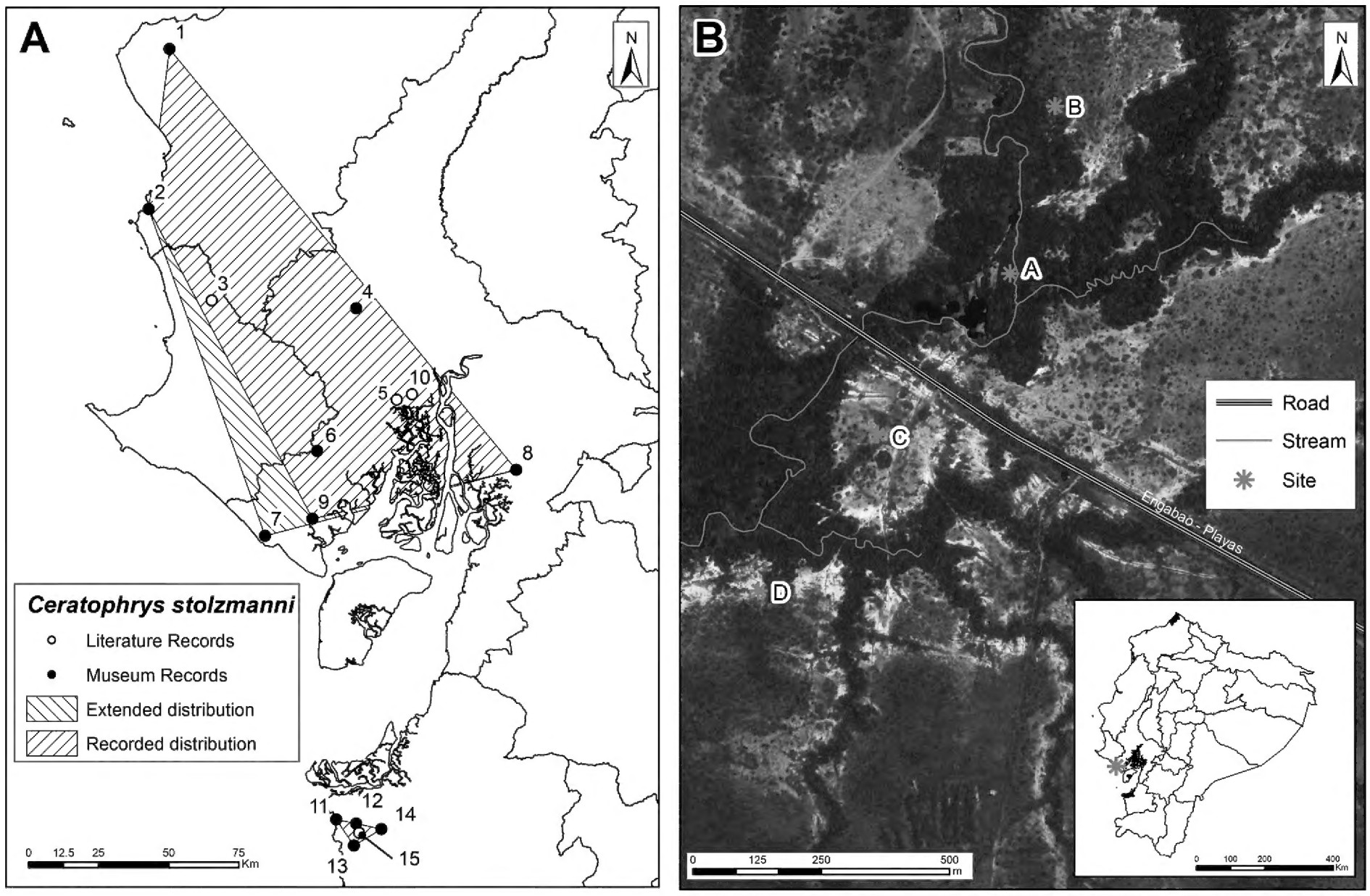

Figure 1. A. Regional map showing distribution of *Ceratophrys stolzmanni* in Ecuador. The study area, and new records, are indicated at "7" on the map; other localities included are listed in Appendix, Table A1. **B.** Map of the study area of El Algarrobo, Engabao; sites A–D are shown. A and B correspond to sites inside the farm, while sites C and D correspond to the grazing area. (Map prepared by Hermel Pineida.)

Table 1. List of species found at Engabao. We report the IUCN red list categories and the total number of individuals observed.

Order	Family	Species	IUCN 2019	Farm sites A, B	Grazing sites C, D
Anura	Bufonidae	*Rhinella horribilis*	NE	9	18
	Ceratophryidae	*Ceratophrys stolzmanni*	VU	2	—
	Hylidae	*Scinax quinquefasciatus*	LC	—	6
	Leptodactylidae	*Engystomops guayaco*	DD	9	15
Squamata	Colubridae	*Leptodeira septentrionalis*	LC	—	11
		Oxyrhopus fitzingeri	LC	—	1
	Gekkonidae	*Lepidodactylus lugubris*	NE	6	1
	Iguanidae	*Iguana iguana*	LC	3	5
		Microlophus occipitalis	LC	66	11
	Teiidae	*Medopheos edracantha*	LC	4	—

unvegetated area near the road; 02°36′41″S, 080°26′14″W; 12 m a.s.l; 10 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R163.

Identification. Individuals of this species are usually nocturnal and semi-arboreal. They can reach up to 1055 mm snout–vent length (SVL), with the females (339–1055 mm) larger than the males (340–965 mm). The tail occupies 23–41% of the total body length. The dorsal coloration ranges from cream to reddish, with 20–70 dark-brown to black spots in addition to dark, intercalated lateral spots that may be present or absent (Duellman 1958; Savage 2002).

This species was the most recorded snake. It was only observed at site C, near the road. One individual was collected coiled, and several were found in an abandoned small house on the roadside during the day, between 10:30 and 12:00. In naturally vegetated areas, they were observed perching in shrubs near the pond, in fully shaded patches, between 17:00 and 23:00.

Distribution. *Leptodeira septentrionalis* is distributed in the lowlands and premontane foothills of the Atlantic slope from southern Texas, USA, to northern Colombia. This species also occurs in the Pacific foothills from Mexico to southwestern Panama and into western South America, including northwestern Peru (Savage 2002). In Ecuador, it has been reported in the provinces of Esmeraldas, Pichincha, Manabí, Los Ríos, El Oro, Guayas, Bolívar, Loja, and Santo Domingo de los Tsáchilas (Kuch 2002; Almendáriz and Carr 2012; Pazmiño-Otamendi 2019).

Oxyrophus fitzingeri (Tschudi, 1845)

Figure 2B

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 specimen (sex undetermined), 534 mm; human settlements (inside an abandoned house); 02°36′38″S, 080°26′14″W; 12 m a.s.l; 14 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R173.

Identification. This species is nocturnal and terrestrial. It has a dark brown coloration with irregular, white or yellow dots. A female is known to measure approximately

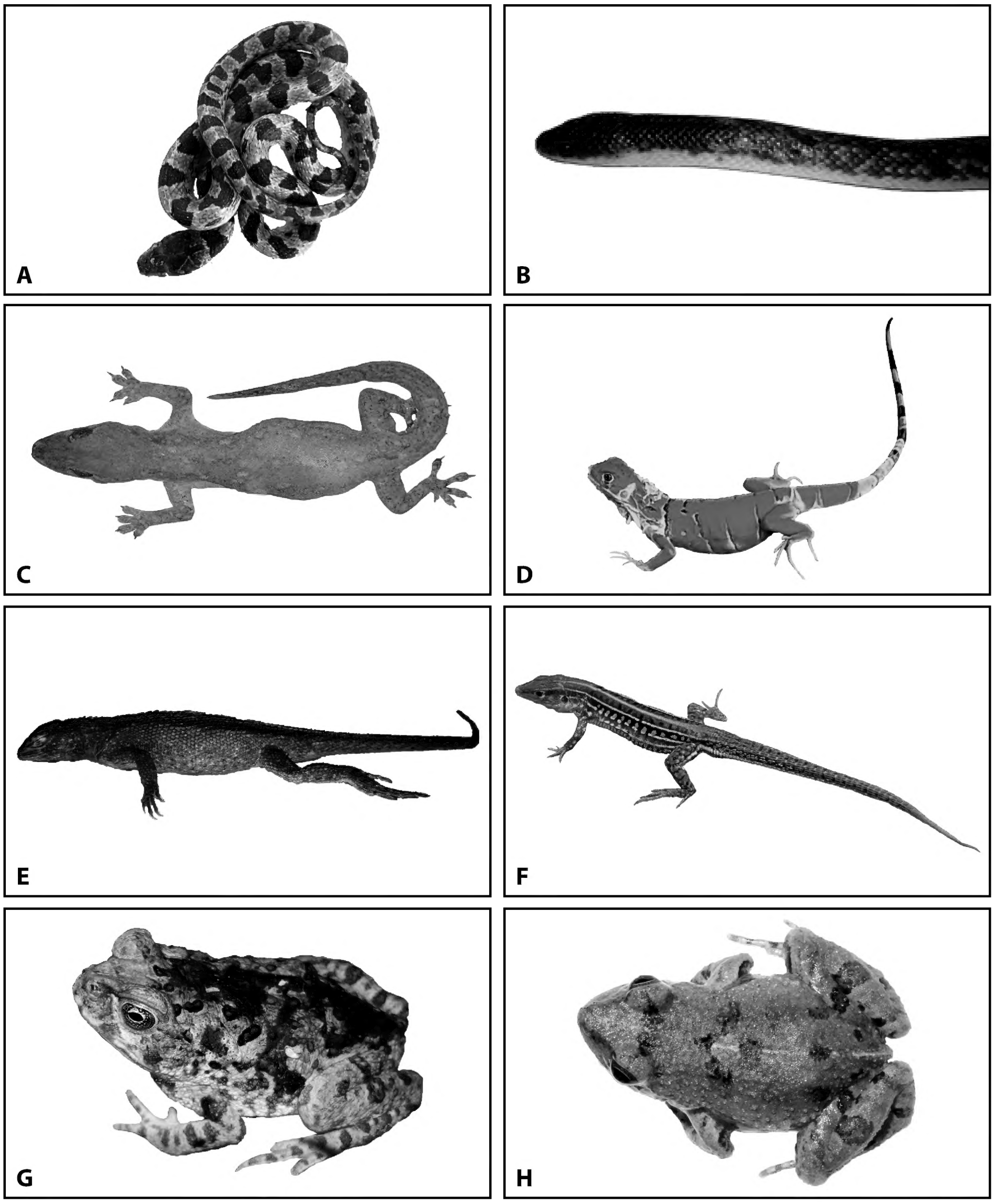

Figure 2. Species found in Hacienda el Algarrobo, Engabao (Playas, Ecuador). **A.** *Leptodeira septentrionalis*. **B.** *Oxyrophus fitzingeri*. **C.** *Lepidodactylus lugubris*. **D.** *Iguana iguana*. **E.** *Microlophus occipitalis*. **F.** *Medopheos edracantha*. **G.** *Rhinella horribilis*. **H.** *Engystomops guayaco.*

714 mm in total length (tail 157 mm) and a male 647 mm in total length (tail 131mm) (Peters and Orejas-Miranda 1970; Pazmiño-Otamendi 2017).

Only one individual of this species was found, at site B. It was hidden in the abandoned, small house along the roadside at 13:00.

Distribution. *Oxyrhopus fitzingeri* occurs in southwestern Ecuador and northwestern Peru. It lives in the tropical and subtropical western zones, between 10–1830 m.a.s.l. In Ecuador, it has been reported from the provinces of Guayas, Loja, El Oro, and Santa Elena (Wallach et al. 2014; Pazmiño-Otamendi 2019).

Family Gekkonidae Oppel, 1811

***Hemidactylus frenatus* (Duméril & Bibron, 1836)**
Figure 2C

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1♀, 53 mm; unvegetated disturbed area near a farmhouse; 02°36′41″S, 080°26′14″W; 12 m a.s.l; 31 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R175 • 1 specimen (sex undetermined), 50 mm; unvegetated disturbed area under a log near a farmhouse; 02°36′35″S, 080°26′13″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R174.

Identification. This species is distinguished from other *Hemidactylus* species by presenting long divided digital pads, non-retractable claws, and digits without basal membranes. It differs from *Lepidodactylus lugubris* in having a claw on all digits, a terminal phalanx, and a free claw on a digital expansion (Savage 2002).

We found this species at both sites using artificial surfaces to perch between 11:00 and 21:30. This species is reported as highly tolerant to the disturbances (Torres-Carvajal and Guerra-Correa 2019), and we mainly observed it in the roofs of farm houses, under zinc sheets, cut logs, and reeds.

Distribution. *Hemidactylus frenatus* is native to tropical Asia and Indo-Pacific region (IUCN 2010). It has been introduced to tropical and subtropical regions around the world, including the Eastern Pacific and South America (Case et al. 1994). In South America, this species has been reported from western Venezuela near the border with Colombia, and, in Ecuador, from the provinces of El Oro, Los Ríos, Esmeraldas, Manabí, Guayas, Sucumbíos, Orellana, Pastaza, and Galápagos (Case et al. 1994; Röll 2001; Torres-Carvajal and Tapia 2011; Pazmiño-Otamendi 2019).

Family Iguanidae Oppel, 1811

***Iguana iguana* (Linnaeus, 1758)**
Figure 2D

Material examined. ECUADOR, province of Guayas, Playas Canton, Ecuador • 1 juvenile, 93 mm; Engabao, Playas Province; 02°36′46″S, 080°26′32″W; 12 m a.s.l; 15 Mar. 2019; S. S. Cuadrado and Y. A. Loor leg.; found in sparse vegetation away from waterbodies.

Identification. This iguanid has a large dorsal crest that extends to more than a third of the tail, enlarged, smooth scales, and a gular sac with spikes. The average SVL of males is 1200–1400 mm, and of females, 900–1100 mm. Females reach 75% of the weight of the males. This species is distinguished from *Polychrus gutturosus* by the presence of dorsal and nuchal ridges and by the strongly compressed tail (Savage 2002; Guerra-Correa and Rodríguez-Guerra 2017).

We found this species at both sites during the day between 10:00 and 15:00. It was mainly observed in vegetation in high perches such as trees and shrubs (3–4 m). These iguanas were observed feeding on leaves or basking in the ground.

Distribution. *Iguana iguana* is occurs in Costa Rica, Panama, and South America, from sea level to 1000 m. It has been introduced to southern Florida and Hawaii. In Ecuador, it has been reported in Santo Domingo de los Tsáchilas, Guayas, Manabí, Esmeraldas, Los Ríos, El Oro, Cañar, and Loja provinces (Guerra-Correa and Rodríguez-Guerra 2017).

***Microlophus occipitalis* (Peters, 1871)**
Figure 2E

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 ♀, 70 mm; unvegetated areas near human settlements and livestock; 02°36′35″S, 080°26′13″W; 12 m a.s.l; 31 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg: UG-R162 • 1 ♂, 74 mm; unvegetated areas near human settlements and livestock; 02°36′35″S, 080°26′13″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.: UG-R167 • 1 ♂, 67 mm; moderate vegetation, sandy ground; 02°36′26″S, 080°26′08″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R166 • 1 ♀, 62 mm; moderate vegetation, sandy ground: 02°36′26″S, 080°26′08″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R168 • 1 ♀, 29 mm; unvegetated areas near human settlements and livestock; 02°36′35″S, 080°26′13″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R164.

Identification. These lizards are distinguished from those of the *M. peruvianus* group in having keeled and imbricated, rather than smooth and granular dorsolateral scales. The largest males are 75 mm SVL and females 58 mm SVL (Mármol-Guijarro 2017). This species was observed at all sites but was more abundant at sites A and B. Most individuals were observed between 10:30 and 15:00 basking on sandy ground, and a few were perching on tree branches close to the ground. This species seems to use vegetated areas characterized by partial shade, and it was also found active and feeding close to the farmhouse and to the cattle enclosure. On a few occasions, some individuals were observed in rocky areas or on perches in full sun. This species tolerates disturbance and anthropogenic activities.

Distribution. *Microlophus occipitalis* is occurs along the western coasts of Ecuador and Peru (Dixon 1975; Watkins 1997), where it lives in dry thickets and deciduous forests. In Ecuador, it is known to occur in the provinces of Loja, Guayas, Santa Elena, and Manabí (Dixon 1975; Mármol-Guijarro 2017).

Family Teiidae Gray, 1827

***Medopheos edracantha* (Bocourt, 1874)**
Figure 2F

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 individual (sex undetermined), 80 mm; moderate vegetation, near livestock; 02°36′36″S, 080°26′12″W; 12 m a.s.l; 27 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-R165.

Identification. This teiid has the following characteristics: frontal scale unique or divided into two; eight longitudinal rows of ventral scales; males with spine-shaped scales on each side of the preanal region; these lizards can reach a cloacal face length of 94 mm (Peters 1964; Harvey et al. 2012).

This was the least-sighted lizard species, recorded only at site A, in a grassy area near the cattle enclosure. This species was active and foraging between 11:00 am and 14:30. We also detected shelter holes in the area.

Distribution. This species is distributed in the western Andes of Ecuador and Peru (Harvey et al. 2012). In Ecuador, it has been reported from the provinces of Loja, Manabí, Guayas, and El Oro (Andrango 2019).

Order Anura
Family Bufonidae Gray, 1825

***Rhinella horribilis* (Wiegmann, 1833)**
Figure 2G

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 specimen (sex undetermined), 130 mm; unvegetated areas near an abandoned house; 02°36′35″S, 080°26′13″W; 12 m a.s.l; Stefania S. Cuadrado, Yelsin A. Loor leg.; record observed.

Identification. This is a brown toad with an SVL of 75–130 mm SVL. It lacks expanded discs on the fingers and has underdeveloped membranes between the toes. This species is difficult to differentiate from *Rhinella marina*, but with the help of x-rays, differences in the bone morphology of these species can be observed in the maxillary, frontoparietal, and occipital regions (Venegas and Ron 2014; Acevedo et al. 2016).

This is a common species found in both natural and disturbed sites in this study. It was found near ponds, on roadsides, in vegetation, and, at the farm, both near the cattle enclosure and the stream. Individuals were active between 17:30 and 22:00.

Distribution. This species is distributed from southern Texas, USA, to northern Peru, west to the Andes. In Ecuador, it occurs on the coast, in western foothills of the Andes, and in the inter-Andean region (Acevedo et al. 2016).

Family Hylidae Rafinesque, 1815

***Scinax quinquefasciatus* (Fowler, 1913)**

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • (5 ♂); identified and located by calls heard close to a waterbody near abundant vegetation; 02°36′49″S, 080°26′28″W; 12 m a.s.l; 29 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; Audio 8 (recorded by Samsung J7 Neo phone; App Voice Recorder) (Supplemental material, Audio file 1).

Identification. This is a medium-sized frog with a SVL of 27.6–38.9 mm. It has a light- or dark-brown dorsum and cream venter. There are abundant tubercles on the back and differs from *Scinax tsachila* which has no tubercles on the back and by the visibility of the calf bones visible through the skin (Read et al. 2019).

Between 17:30 and 21:30, this species was only found near the pond at site B, where an auditory recording was made.

Distribution. This species is distributed in the Pacific lowlands of Colombia and Ecuador (Frost 2016). In Ecuador, it is found in the provinces of Esmeraldas, Pichincha, Santo Domingo de los Tsáchilas, Manabí, Los Ríos, Guayas, Cañar, and El Oro (Ron 2018).

Family Leptodactylidae Werner, 1896

***Engystomops guayaco* (Ron, Cannatella & Coloma, 2005)**
Figure 2H

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 specimen (sex undetermined), 15 mm; near a waterbody near vegetation: 02° 36′49″S, 080°26′28″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-AN135 • 1 specimen (sex undetermined), 20 mm; near a waterbody near moderate vegetation; 02°36’49”S, 080°26′28″W; 12 m a.s.l; 26 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-AN105 • 1 specimen (sex undetermined), 16 mm; near a waterbody near moderate vegetation; 02°36′49″S, 080°26′28″W; 12 m a.s.l; 28 Apr. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-AN136.

Identification. This frog measures 15.45–20.98 mm SVL. There are scattered tubercles on the back, and the snout is truncated in dorsal view and rounded in side view. It is similar in size to *Engystomops montubio* and *Engystomops randi* but differs from those species in having less extensive lateral fringes on its feet and shorter interdigital membranes. *Engystomops guayaco* differs from *E. randi* in having the shortest edge and less abundant dorsal tubers (Ron et al. 2005). *Engystomops pustulatus* is a larger species, with males reaching 27 mm and females 31 mm.

We documented *E. guayaco* in all sites, both visually and by auditory calls. It was found in the less disturbed dry thorn scrub at sites C and D, calling from hollows near the pond, and at sites A and B calling in vegetation near puddles formed after few rains. Animals were calling or active from 15:00 to 22:00.

Distribution. *Engystomops guayaco* is endemic to Ecuador and ocurrs in the southwestern lowlands of the country (Frost 2016).

Family Ceratophryidae Tschudi, 1838

***Ceratophrys stolzmanni* (Steindachner, 1882)**
Figure 3A, B

Material examined. ECUADOR, province of Guayas, Playas Canton, Engabao • 1 specimen (sex undetermined), 49 mm; moderate vegetation near a waterbody;

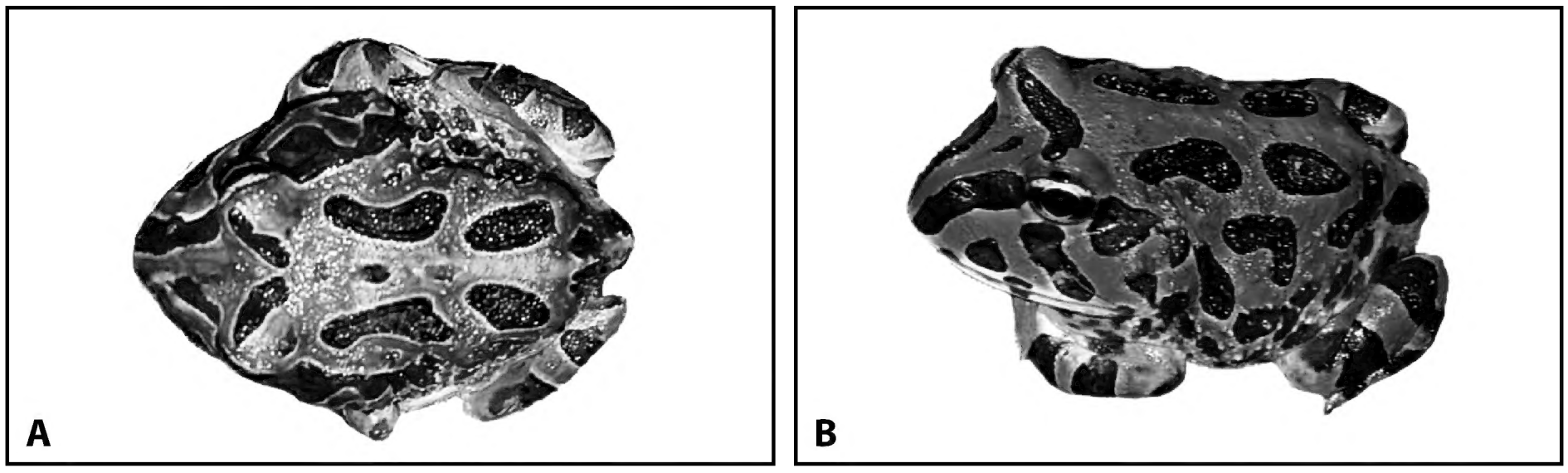

Figure 3. *Ceratophrys stolzmanni* found in Hacienda el Algarrobo, Engabao (Playas, Ecuador). **A.** Brown morph. **B.** Green morph.

02°36′24″S, 080°26′03″W; 12 m a.s.l; 1 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-AN103. 1 individual (sex undetermined), 54 mm; moderate vegetation near a waterbody; 02°36′24″S, 080°26′03″W; 12 m a.s.l; 1 Mar. 2019; Stefania S. Cuadrado, Yelsin A. Loor leg.; UG-AN104.

Identification. *Ceratophrys stolzmanni* differs from all species which inhabit the Ecuadorian coast in having an extremely wide head and mouth, and in bearing dark markings on the backs. The SVL of this species ranges from 48 to 82 mm. The body color varies from brown to green, both dark and light. The soles of the feet have spadices, which these frogs use to bury themselves. It differs from *Ceratophrys cornuta* and *Ceratophrys testudo* in lacking horn-shaped dermal appendages on the eyes and having keratinized appendages on the feet (Lynch 1982; Rodríguez and Duellman 1994).

In this study, we found only two individuals, and both were at the same site. These were in the remnant patches of dry thorn scrub on the farm. One individual exhibited a dark brown (Fig. 3A) dorsal pattern, while the other exhibited a dark green dorsal pattern (Fig. 3B). They were around small puddles after a rain. These individuals were in the same area, separated by 1 m, at 19:00. Previous studies have reported that this species is cannibalistic and that it also feeds on other frogs like *Trachycephalus jordani* and on snakes like *Leptodeira septentrionalis*. We commonly found *L. septentriolis* during our surveys, and this species could be a feeding resource for *C. stolzmani* (Székely et al. 2019).

Distribution notes. *Ceratophrys stolzmani* is known to occur in southwestern Ecuador, in the provinces of Manabí, Santa Elena, Guayas, and El Oro, and in Tumbes Department, northwestern Peru (Frost 2016). The previously known localities, both in Ecuador, nearest to our site are Playas, Guayas, and Loma Alta, Santa Elena; these are 18 km southwest and 86 km northeast of our site, respectively. These earlier-reported localities are the sources of the paratypes used for the species' description by Peters (1967), who mentioned that there was only the dark-brown (reddish brown or darker black) morph in Playas, but we report not only this brown morph but also the light-green morph with dark marks (Fig. 3). The next closest localities are Cerecita, Guayaquil Canton, 35.4 km to the northeast, and Bosque Protector Cerro Blanco 67.5 km to the northeast. (Figure 1). *Ceratophrys stolzmanni* has been previously recorded from three types of ecosystems: dry thorn scrub (Manabí, Guayas province; 123 km from Engabao), tropical dry forest (Cerro Blanco, Guayas province, 67.51 km from Engabao, and Reserva Ecológica Arenillas, El Oro province, 104 km from Engabao), and garua forest (Loma Alta, Santa Elena province; 86 km from Engabao) (Appendix, Table A1).

Discussion

The number of individuals per species that we observed varied, and the number of species that we recorded for the dry thorn scrub ecosystem was low in comparison to the number found elsewhere in this ecosystem by Torres-Carvajal et al. (2018) and Ron et al. (2019), who listed 16 species of amphibians and 45 species of reptiles in BiowebEcuador. Such differences between studies could be influenced by the effects of cattle raising or due to the time of year (dry versus wet season). One of the main effects of heavy grazing on the reptile assemblage is an increase in the abundance of resilient species (Read 2002), exemplified here by the high capture rate of *Microlophus occipitalis*. On the other hand, a reduced diversity is expected in ecosystems altered by cattle raising, which modifies the landscape, mainly by reducing the vegetation cover. Thus, availability of shelter and food becomes limited for some herpetofauna, which allows one or a few opportunistic species to dominate. At sites C and D, in particular, there was substantial grazing activity and heavy traffic by cattle, which hardens the soil and reduces the space accessible for wildlife, as suggested by Paladines (2003). Such conditions may explain the lower detectability of herpetofauna in these transects.

The presence of amphibians is dependent on water availability (Lion et al. 2019), and, for instance, *C. stolzmani* and *Engystomops* spp., including *E. guayaco*, reduce their activity significantly due to the lack of rain, and their abundance increases during the rainy season which coincides with the reproductive period (Peters

1967; Narváez and Ron 2017). During our study, rain was scarce (there was rain on only two days during the entire sampling period, as also reported by the local people), explaining the low detection rate of diversity and abundance. Nonetheless, the low detectability of non-amphibian species may be also linked to the low number of sampling sites. We recommend performing recurrent surveys at the dry thorn shrub ecosystem, to study population dynamics of amphibians and reptiles and, in particular at Engabao to study the effects that anthropogenic activities, which are now permanently developed in the area.

Our list of species is the first effort to inventory the herpetofauna of the dry thorn scrub ecosystem in Playas Canton, an area previously recognized as the costal desert of the Guayas province (Peters 1967). We highlight the importance of characterizing the biodiversity in areas undergoing economic development, as there are still remnant patches which can still be protected or managed to mitigate the effects of activities such as livestock production and agriculture. As we observed greater diversity of the herpetofauna in the less impacted areas near the farm in comparison to areas used for grazing in dry thorn scrub, we suggest using herpetofauna as a bioindicator of the effects of heavy cattle and towards the implementation of environmentally friendly livestock practices. In this sense, recommendations might include alternative strategies for feeding cattle, such as restricting feeding to enclosure areas, instead of letting cattle graze freely in the dry thorn scrub. As recognized by the Food and Agriculture Organization of the United Nations (FAO) (Sangoluisa 2017), increased efficiency in the use of resources increases resilience, improves the management of farms, and reduces disturbances in natural remnant ecosystems.

We report *Ceratophrys stolzmanni*, a species classified as Vulnerable by the IUCN (International Union for the Conservation of Nature), from an altered ecosystem 55 years after it was last collected in the area (Peters 1967). This species was described as a good burrower (Székely et al. 2016, 2019), which might allow it to persist in harsh environments. We emphasize the importance of maintaining small patches of native vegetation within production areas. Native vegetation patches may represent the last remnants where *C. stolzmanni* can survive.

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Authors' Contributions

SSC and YAL collected the data, identified the specimens, and wrote the manuscript. AEN also identified the specimens and wrote the manuscript.

References

Acevedo AA, Lampo M, Cipriani R (2016) The cane or marine toad, *Rhinella marina* (Anura, Bufonidae): two genetically and morphologically distinct species. Zootaxa 4103 (6): 574–586. https://doi.org/10.11646/zootaxa.4103.6.7

Almendáriz A, Carr J (2012) Lista actualizada de los anfibios y reptiles registrados en los remanentes de bosque de la Cordillera de la Costa y áreas adyacentes del suroeste del Ecuador. Escuela Politécnica Nacional 30: 184–194.

Altamirano-Benavides M, Ortega-Andrade H (2010) Herpetofauna Del Ecuador: El Chocó Esmeraldeño. Guía de identificación y Patrones de Diversidad. Museo Ecuatoriano de Ciencias Naturales, Quito, Ecuador, 232 pp.

Amador-Oyola L (2016) Similitud Biogrográfica y ecológica de las comunidades de anuros del occidente de Ecuador. Master dissertation, Universidad de Guayaquil, Guayaquil, Ecuador, 74 pp.

Amador L, Brito G (2013) Notes on the distribution and conservation of *Ceratophrys stolzmanni* (Steindachener, 1882) (Anura: Ceratophryidae) in Ecuador. Yachana 2 (2): 123–126.

Amador L, Martínez C (2011) Anfibios presentes en cuatro localidades de la Cordillera Chongón–Colonche, Ecuador. Ecuador. Boletín Técnico, Serie Zoológica 10: 55–68.

Andrango, MB (2019). *Medopheos edracanthus*. In: Torres-Carvajal O, Pazmiño-Otamendi G, Salazar-Valenzuela D. 2019. Reptiles del Ecuador. Version 2019.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Medopheos%20edracanthus. Accessed on: 2020-4-19.

Case T, Bolger D, Petren K (1994). Invasions and competitive displacement among house geckos in the tropical Pacific. Ecology 75 (2): 464–477. https://doi.org/10.2307/1939550

Climate-Data.org (2019) Clima Engabao: temperatura, climograma y tabla climática para Engabao. https://es.climate-data.org/america-del-sur/ecuador/provincia-del-guayas/engabao-289662/. Accessed on: 2019-07-12.

Deichmann JL, Lima AP, Williamson GB (2011) Effects of geomorphology and primary productivity on Amazonian leaf litter herpetofauna. Biotropica 43 (2): 149–156. https://doi.org/10.1111/j.1744-7429.2010.00683.x

Dixon JR, Wright JW (1975) A review of the lizards of the iguanid genus *Tropidurus* in Peru. Natural History Museum of Los Angeles County, Contributions in Science 271: 1–39.

Duellman W (1958) A monographic study of the colubrid snake genus *Leptodeira*. Bulletin American Museum of Natural History 114: 1–152.

Frost DR (2016) Amphibian species of the world: an online reference. Version 6.0 American Museum of Natural History, New York,

USA. http://research.amnh.org/herpetology/amphibia/index.html. Accessed on: 2019-07-12.

Guerra-Correa E, Rodríguez-Guerra A (2017) *Iguana iguana*. In: Torres-Carvajal O, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2018.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Iguana%20iguana. Accessed on: 2018-12-14.

Harvey M, Ugueto G, Gutberlet JrR (2012) Review of teiid morphology with a revised taxonomy and phylogeny of the Teiidae (Lepidosauria: Squamata). Zootaxa 3459 (1): 1–156. https://doi.org/10.11646/zootaxa.3459.1.1

Heatwole H (1982) A review of structuring in herpetofaunal assemblages. US Fish and Wildlife Service Wildlife Research Report 13: 1–19.

IUCN SSC Amphibian Specialist Group (2018) *Ceratophrys stolzmanni*. The IUCN Red List of threatened species 2018: e.T56341A89204905.https://www.iucnredlist.org/species/56341/89204905. Accessed on: 2020-3-24.

IUCN (2010) The IUCN Red List of threatened species. http://www.iucnredlist.org. Accessed on: 2020-4-13.

Kuch U (2002) Snake records from Bolívar province, Ecuador. Herpetozoa 15: 182–184.

Lion MB, Mazzochini GG, Garda AA, LeeTM, Bickford D, Costa GC, Fonseca CR (2019) Global patterns of terrestriality in amphibian reproduction. Global Ecology and Biogeography 28 (6): 744–756. https://doi.org/10.1111/geb.12886

Lynch J (1982) Relationships of the frogs of the genus *Ceratophrys* (Leptodactylidae) and their bearing on hypotheses of Pleistocene forest refugia in South America and punctuated equilibria. Systematic Biology 31 (2): 166–179. https://doi.org/10.1093/sysbio/31.2.166

MAE (2013) El sistema de clasificación de ecosistemas de Ecuador Continental. Subsecretaría de Patrimonio Natural, Quito, Ecuador, 232 pp.

Markle CE, Chow-Fraser G, Chow-Fraser P (2018) Long-term habitat changes in a protected area: implications for herpetofauna habitat management and restoration. PloS ONE 13 (2): e0192134. https://doi.org/10.1371/journal.pone.0192134

Mármol-Guijarro A (2017) *Microlophus occipitalis*. In: Torres-Carvajal O, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2018.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Microlophus%20occipitalis. Accessed on: 2018-12-13.

MECN, Jocotoco, Ecominga (2013) Herpetofauna en áreas prioritarias para la conservación: el sistema de reservas jocotoco y ecominga. Serie de Publicaciones del Museo Ecuatoriano de Ciencias Naturales, Fundación para la Conservación Jocotoco, Fundación Ecominga, Quito, Ecuador, 407 pp.

Narváez A, Ron S (2017) Spawning behaviour of *Engystomops pustulatus* (Anura: Leptodactylidae). Journal of Natural History 51 (3–4): 267–275. https://doi.org/10.1080/00222933.2016.1251983

Paladines R (2003) Propuesta de conservación del Bosque seco en el Sur de Ecuador. Lyonia 4: 183–186.

Pazmiño Otamendi G (2019) *Hemidactylus frenatus*. In: Torres-Carvajal O, Pazmiño-Otamendi G, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2019.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Hemidactylus%20frenatus. Accessed on: 2020-4-19.

Pazmiño-Otamendi G (2019) *Leptodeira septentrionalis*. In: Torres-Carvajal O, Pazmiño-Otamendi G, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2019.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Leptodeira%20septentrionalis. Accessed on: 2020-4-19.

Pazmiño-Otamendi G (2017) *Oxyrhopus fitzingeri*. In: Torres-Carvajal O, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2018.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Oxyrhopus%20fitzingeri. Accessed on: 2018-12-13.

Peters J (1967) The generic allocation of the frog *Ceratophrys stolzmanni* Steindachner, with the description of a new subspecies from Ecuador. Proceedings of the Biological Society of Washington 80: 105–112.

Peters J (1964) The lizard genus *Ameiva* in Ecuador. Bulletin of the Southern California Academy of Sciences 63 (3): 113–127.

Peters J, Orejas-Miranda B (1970) Catalogue of the Neotropical Squamata: part I. Snakes. United States National Museum Bulletin 297: 1–347.

Read JL (2002) Experimental trial of Australian arid zone reptiles as early warning indicators of overgrazing by cattle. Austral Ecology 27 (1): 55–66. https://doi.org/10.1046/j.1442-9993.2002.01159.x

Read M, Ron S, Pazmiño-Armijos G (2019) *Scinax quinquefasciatus*. In: Ron S R, Merino-Viteri A, Ortiz DA (Eds) Anfibios del Ecuador. Version 2019.0. Museo de Zoología, Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/amphibiaweb/FichaEspecie/Scinax%20quinquefasciatus. Accessed on: 2019-11-19.

Reyes-Puig C, Almendáriz C, Torres-Carvajal O (2017) Diversity, threat, and conservation of reptiles from continental Ecuador. Amphibian and Reptile Conservation 11: 51–58.

Rodríguez L, Duellman W (1994) Guide to the frogs of the Iquitos Region, Amazonian Peru. Special Publication, Museum of Natural History, Universityof Kansas 22: i–vi, 1–80, pls 1–12. https://doi.org/10.5962/bhl.title.7937

Röll B (2001) Gecko vision—retinal organization, foveae and implications for binocular vision. Vision Research 41: 2043–2056. https://doi.org/10.1016/S0042-6989(01)00093-1

Ron, S, Coloma, L, Cannatella, D (2005) A new cryptic species of *Physalaemus* (Anura: Leptodactylidae) from western Ecuador with comments on the call structure of the *P. pustulosus* species group. Herpetologica 61 (2): 178–198 https://doi.org/10.1655/04-38

Ron SR (2018) Base de datos de la colección de anfibios del Museo de Zoología (QCAZ). Versión 1.0. Pontificia Universidad Católica del Ecuador. https://bioweb.bio/portal/. Accessed on: 2019-7-12.

Ron S, Merino-Viteri A, Ortiz D (2019) Anfibios Ecuador. In: Museo Zoología Pontifcia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/amphibiaweb/. Accessed on: 2019-7-12.

Salvatierra B, Ortega J, Amador- Oyola L (2010) Evaluación ecológica rápida de la herpetofauna en la cordillera Chongón-Colonche, Ecuador. Consejo Editorial Universidad De Guayaquil, Guayaquil, Ecuador, 51pp.

Sangoluisa P (2017) Ganadería climáticamente inteligente. Integrando la reversión de la degradación de tierras y reduciendo los riesgos de desertificación en provincias vulnerables. Ministerio de Agricultura y Ganadería MAG, Quito, Ecuador, 37pp.

Savage J (2002) The amphibians and reptiles of Costa Rica: a herpetofauna between two continents, between two seas. University of Chicago Press, Chicago, USA, 399 pp.

Székely D, Gaona F, Székely P, Cogălniceanu D (2019) What does a Pacman eat? Macrophagy and necrophagy in a generalist predator (*Ceratophrys stolzmanni*). PeerJ 7: e6406. https://doi.org/10.7717/peerj.6406

Székely P, Székely D, Armijos-Ojeda D, Jara-Guerrero A, Cogălniceanu D (2016) Anfibios de un bosque seco tropical: Reserva Ecológica Arenillas, Ecuador. Revista Ecosistemas 25 (2): 24–34. https://doi.org/10.7818/ecos.2016.25-2.04

Torres-Carvajal O, Guerra-Correa E (2019) *Lepidodactylus lugubris*. In: Torres-Carvajal O, Pazmiño-Otamendi G, Salazar-Valenzuela D (Eds) Reptiles del Ecuador. Version 2019.0. Museo Zoología Pontificia Universidad Católica del Ecuador. https://bioweb.bio/faunaweb/reptiliaweb/FichaEspecie/Lepidodactylus%20lugubris. Accessed on: 2019-10-9.

Torres-Carvajal O, Pazmiño-Otamendi G, Salazar-Valenzuela D (2018) Reptiles del Ecuador. Version 2018.0. Museo Zoología Pontificia Universidad Católica del Ecuador. https://bioweb.bio/

faunaweb/reptiliaweb/. Accessed on: 2019-7-12.
Torres-Carvajal O, Tapia W (2011) First record of the common house gecko *Hemidactylus frenatus* Schlegel, 1836 and distribution extension of *Phyllodactylus reissii* Peters, 1862 in the Galápagos. Check List 7 (4): 470–472. https://doi.org/10.15560/7.4.470
Tuberville T, Willson J, Dorcas M, Gibbons J (2005) Herpetofaunal species richness of southeastern national parks. Southeastern Naturalist 4 (3): 537–569. https://doi.org/10.1656/1528-7092(2005)004[0537:hsrosn]2.0.CO;2
Uetz P, Hošek J (2016) The reptile database. http://www.reptile-database.org. Accessed on: 2020-4-9.
Valencia-Aguilar A, Cortés-Gómez AM, Ruiz-Agudelo CA (2013) Ecosystem services provided by amphibians and reptiles in Neotropical ecosystems. International Journal of Biodiversity Science, Ecosystem Services & Management 9 (3): 257–272. https://doi.org/10.1080/21513732.2013.821168
Venegas P, Ron S (2014) First records of *Rhinella poeppigii* (Tschudi 1845) from Ecuador, with a distribution map (Anura: Bufonidae). Herpetology Notes 7: 713-716.
Wallach V, Williams KL, Boundy J (2014) Snakes of the world: a catalogue of living and extinct species. CRC Press, Boca Raton, Florida, USA, 1227 pp.
Watkins GG (1997) Inter-sexual signalling and the function of female coloration in the tropidurid lizard *Microlophus occipitalis*. Animal Behaviour 53 (4): 843–852. https://doi.org/10.1006/anbe.1996.0350

Appendix

Table A1. Localities where *Ceratophrys stolzmanni* is reported. The records were gathered from the literature references and from museum records, and the locality included by this work. The locality numbers are referred in the Figure 1.

Locality	Province	Locality	Source
1	Manabí	El Sauce	Fundación Herpetológica Gustavo Orcés (FHGO)
2	Manabí	Puerto López	Zoology Museum at the Pontifical Catholic University of Ecuador (QCAZ)
3	Santa Elena	Loma Alta	Amador and Martínez 2011
4	Guayas	Isidro Ayora	Fundación Herpetológica Gustavo Orcés (FHGO) (M)
5	Guayas	Cerro Blanco	Amador-Oyola 2016
6	Guayas	Cerecita	Zoology Museum at the Pontifical Catholic University of Ecuador (QCAZ)
7	Guayas	Engabao	Current work
8	Guayas	Cerro Más Vale	Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ)
9	Guayas	Playas	Peters 1967; Museum of Vertebrate zoology (MVZ)
10	Guayas	Bosque Protector La Prosperina	Amador and Brito 2013 (L)
11	El Oro	Huaquillas-Arenillas	Museo de Zoología de la Pontificia Universidad Católica del Ecuador (QCAZ) (M)
12	El Oro	Huaquillas-Arenillas	Museo de Zoología Universidad de Azuay (MZUA) (M)
13	El Oro	Huaquillas-Arenillas	Museo Gustavo Orces (EPN) (M)
14	El Oro	Huaquillas-Arenillas	VIVARIUM (M)
15	El Oro	Huaquillas-Arenillas	Székely et al. 2016 (L)

Supplemental File

Audio file 1. Calls of *Scinax quinquefasciatus* recorded on 29 March 2019 at Engabao, Playas Canton, province of Guayas, Ecuador.